Dung Duc Tran et al. Assessing impacts of dike construction on the flood dynamics in the Mekong Delta

Responses to Reviewer#1 comments

By Dung Duc Tran

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General comment: The authors used a hydrology model to evaluate the relationship between dike construction and the hydrography during the flood season in the Vietnamese Mekong Delta. In general, this study is interesting and important, considering the frequency of flood events and high-density dike constructions. However, the impact of artificial construction on flood dynamic obviously has been extensively studied in many previous literature, so I would not say this is a novel study although the numerical modeling method is rarely seen. There are several issues that needed to be addressed before the paper can be accepted in HESS. I recommend a major revision with further review by the editors and referees.

Response: We highly appreciate Reviewer#1 for the dedicated reviews and valuable comments on the manuscript. Please find below our details responses and corresponding revisions.

1. Comment P1, Ln19: I expect the authors to explain and define some technical terms/words at the first time in the paper, such as the high-dike and semi-dike. In addition, please use the consistent word throughout the paper, for example, correct the August-dike to semi-dike.

Response: We agree with Rewiewer#1 to define some key terms (i.e. high-dike, semi-dike) at the beginning of the paper. The high-dikes we considered in the study are the closed polders/compartments used mainly for protecting triple-rice production. We add short text to describe dike types in the Abstract and further elaborate on these terms in the main text.

Added text to the Abstract: "*for triple-rice production*"

Regarding the semi-dike, we define it in the Introduction section of the manuscript only because this dike is not considered as a factor causing flood risk downstream. However, we will replace the "semi-dike" term with "low-dike" term. This term helps readers understand the meaning easily in reference to our use of "high-dike". In addition, the "low-dike" term will be used throughout the manuscript to ensure the consistency.

2. Comment P1, Ln22-23: This sentence needs to be rephrased:...is assessed through the flood hydrographs modeling under different dike density scenarios in 2011 and 2013.

Response: We will rephrase the sentence as Reviewer#1's comment.

Rephrased text: "*This paper assesses the hydraulic impact of upstream dike construction on the flood hazards downstream the Mekong Delta. To do this, the existing Mekong delta one-dimensional (1D) hydrodynamic model combined with a quasi-two dimensional (2D) approach was first calibrated and validated with floods in 2011 and 2013, then used to explore the water dynamics downstream under extensive high-dike developments in An Giang and Long Xuyen Quadrangle*"

3. Comment P2 Ln2: What is a Quadrangle? I don't think it is a right word for hydrology study. Try to use the watershed name.

Response: We agree with the reviewer that using a watershed name is better in a hydrology study. But in our case, "Long Xuyen Quadrangle" term is widely used in literature (Hung et al., 2012, 2014a, 2014b, Manh et al., 2014a, 2015; Mekong Delta Plan, 2013), referring to one of the two geographical floodplains in the Vietnamese Mekong Delta (the other floodplain is Plain of Reeds). In addition, Figure 1 shows the geographical extent of the Long Xuyen Quadrangle in the manuscript which helps readers know the location of this floodplain. We also described the Long Xuyen Quadrangle in the Introduction section.

4. Comment P2, Ln18-20: I don't suggest to write the future work in the abstract, since it is not part of the authors' work reported in this paper. Also, the authors mentioned that the historical monitoring data are absent, so it is actually difficult or even impossible to do the future assessments.

Response: We fully agree with Reviewer#1. These sentences will be removed from the Abstract.

5. Comment P3, Ln2-8: The information of economic and food production is too detailed within this paper. Try to shorten this part.

Response: We agree and will shorten this part in the revised manuscript. In particular we will merge two paragraphs about flood benefits and damages into one and remove some unnecessary details.

6. Comment P3, Ln9-17: The economic cost and loss are not related to the scientific question in this paper.

Response: We agree with the reviewer to shorten the content in the revised manuscript.

7. Comment P5, Ln1-3: The authors used one point observation to demonstrate a clear correlation between the dike construction and water level. There is no clear evidence showing the cause and effect between the dike construction and water level. In addition, I don't suggest to write one data point in the introduction part.

Response: We agree with Reviewer#1 that one point observation could not be used to demonstrate a clear correlation between the dike construction and the increase in water levels. We use this example to highlight a public concern about the flood risk downstream caused by upstream dike construction. It was confused for readers when we used the "suggest there is a clear correlation" phrase in the manuscript. We will rephrase this sentence as one of the evidence/example indicating flood risks downstream which would be potentially exacerbated by the large-scale high-dike constructions. This evidence is also presented in a recent study by Triet et al. (2017).

Text would be changed as follows: *"For example, the water level observed in 2011 at the upstream station of Tan Chau was 0.63 m lower than in 2000 (4.27m and 4.90 m), whereas the water levels observed in Can Tho were 0.36 m higher in 2011 than in 2000 (2.15 m and 1.79 m, respectively*). *This thus indicates a correlation between the increase in high dike construction in the floodplains and the increase of water level and flood risks downstream in and around the city of Can Tho".*

8. Comment P5, Ln9-24: I recommend the authors to cite the reference right after each reason of flood risk (Ln10-11), instead of explaining each reference separately in detailed. The other reasons associated with the flood risks are not strongly related to the scientific questions discussed in this paper. And, are these studies focus on the same study site (Vietnamese Mekong Delta) as well?

Response: We thank Reviewer#1 for this useful suggestion. We will rewrite this paragraph to better connect references to different reasons of flood risks. We will also revise the text to link the information with the objective of the paper. We will also add text to inform the study site (VMD) of the referenced papers.

Revised text: *"Several studies have concluded that flood risks in the VMD delta have increased over the last decades due to a number of reasons: climate change, sea level rise, hydropower development, land subsidence, and local rainfall. In the complex hydrodynamic context of the delta, flood risks are assessed in various forms by a variety of authors: flood extent and duration, flood depth or floodwater level, or river water levels. Wassmann et al. (2004) used a hydraulic model to conclude the increase in water level in the delta caused by sea level rise under changing climate. Fujihara et al. (2015) conducted a study to identify the possible impacts of the runoff upstream, sea level rise, and land subsidence on the floodwater level rise. Lauri et al., (2012) and Hoang et al., (2016) assessed the impacts of projected climate change and reservoir operation on the future changes in the Mekong River hydrology. Some other studies showed the impacts of climate change and sea level rises on flood propagation, flood inundation and sediment transport (Apel et al., 2012; Hung, 2012b; Quang et al., 2012; Manh et al., 2014)."*

9. Comment P6 Ln22-23: I suggest the authors highlight the gap of modelling approach within this manuscript. The previous studies of modelling approaches and applications should be addressed in the introduction as well.

Response: We will highlight the important gaps of the modelling approach, namely the lack of mechanistic understanding about impacts of upstream high-dike development on downstream flood hazards, and the missing quantifications of the water balance. We will add text to emphasize these two gaps in the revised manuscript.

Added text to the revised manuscript: *"Despite rapid development of high-dike system for triple rice production in the upper Mekong Delta, few modeling studies assessed the resulting implication of such developments on floodwater regimes. As a result, understandings about the changing regimes and their driving factors remain very limited. Additionally, while previous studies focused strongly on variation of peak water levels based on monitoring data or model results, no study analyzed changes in the floodwater balance. Since the water balance analyses are important to understand where floodwater is distributed under different dike scenarios, we use a 1D-quasi2D modelling approach to address this knowledge gap. This approach allows to test the hypothesis that large-scale high-dike constructions would reduce the flood retention capacity of the floodplains and increase water levels (and associated flood risks) along rivers downstream."*

10. Comment P8 Ln4: What is a.m.s.l?

Response: We will clarify the term of "a.m.s.l" as "*above mean sea level*".

11. Comment P9 Ln3-5: Again, move these explanations forward to help readers understand their meanings.

Response: We agree with Reviewer#1 to move these explanations forward to help readers understand the characteristics of low dikes and high dikes. In the revised manuscript, these explanations will be moved forward in the first paragraph of Section 2 (**Study area**).

12. Comment P8 Methodology section: I think a more detailed introduction of the hydrologic model and software are necessary, including the governing equations and physics used in the model, their applications, pros and cons, etc. The authors can't just cite the references.

Response: We will add a brief introduction of the hydrologic model and software. In the revised manuscript, we will also present detailed introduction in the Supplement.

Added text to the revised manuscript: "*The one-dimensional hydrodynamic model based on Mike 11 software developed by the Danish Hydraulic Institute (DHI). The model is an implicit finite difference model for one-dimensional unsteady flow computation. In addition, it could be applied to quasi-two dimensional (quasi-2D) flow simulation to perform detailed modelling of rivers, including special treatment of floodplains, road overtopping, culverts, gate openings and weirs (Doulgeris et al., 2012). The model is capable of using kinematic, diffusive or fully dynamic, vertically integrated equations of conservation of continuity and momentum (the Saint-Venant equations) for solving complex flow and mass transport problems* (Patro et al., 2009; Dung et al., 2011; Manh et al., 2014b). *Therefore, it was used to represent the river network and its floodplains for the Mekong Delta. Detailed information about the equations and computational components is shown in the Supplement 4*."

Text added in the Supplement:

The Saint-Venant equations are formulated as follows (DHI, 2011)*:*

Continuity equation:

$$\frac{\partial Q}{\partial t}+\frac{\partial A}{\partial t}=q$$

Momentum equation:

$$\frac{\partial Q}{\partial t}+\frac{\partial\left(\frac{\propto Q^2}{A}\right)}{\partial x}+gA\frac{\partial h}{\partial x}+\frac{gQ|Q|}{C^2AR}=0$$

Where

Q-discharge [m^3/s]

A-flow area [m^2]

q-the lateral inflow [m^2/s]

h-stage above datum [m]

C-Chezy resistance coefficient [$m^{1/2}/s$]

R-hydraulic or resistance radius [m]

∝-*momentum distribution coefficient*

13. Comment P11 Ln5-7: How did you select these Manning coefficients? Any references? And, try to use a clearer word rather than “global” to avoid misunderstanding.

Response: We agree to explain our selection of the Manning Coefficients in the revised manuscript and will add references. Beside, “global” term is replaced with “generic” and the sentence will be clarified to explain our input for a coefficient for the whole rivers in the network.

Explained how to select the Manning Coefficients and references: “*The initial river roughness were estimated based upon the range of roughness values corresponding to types of rivers and canals provided by various publications (Chow, 1959; Fabio et al., 2010; Dung et al., 2011)”.*

The text will be rewritten as follows: “*These roughness numbers are represented as manning coefficients in the model. Referring to Chow (1959), we first set generic manning coefficients of 0.02 (irrigation channel, straight, in hard-packed smooth sand), 0.025 (earth channel exacerbated in alluvial silt soil, with deposits of sand on bottom and growth of grass), and 0.033 (natural channel, somewhat irregular side slopes, very little variation in cross section) respectively for the whole river branches for the three initial runs to identify the changes in water levels and discharge in the main rivers*”

14. Comment P14 Ln19: I’m confused about the Q-Q plots in figure 3. What does each point represent? Are they daily simulated and observed streamflow? If yes, the authors should consider the time-series plot for the streamflow results.

Response: Each point in the Q-Q plot in Figure 3 represents the correlation between daily simulated and observed streamflow, based on Correlation Coefficient (R^2) and Nash-Sutcliffe Efficiency (NSE).We agree with Revieever#1 to present some time-series plots in the manuscript instead of the Q-Q plots. Another reason is that Table 1 already shows the NSE and R^2. All the Q-Q plots will be presented only in the Supplement. We will also add all time-series plots to the Supplement. Figure 3 will be captioned as “Time series of simulated and observed flows in 2011 at representative stations”.

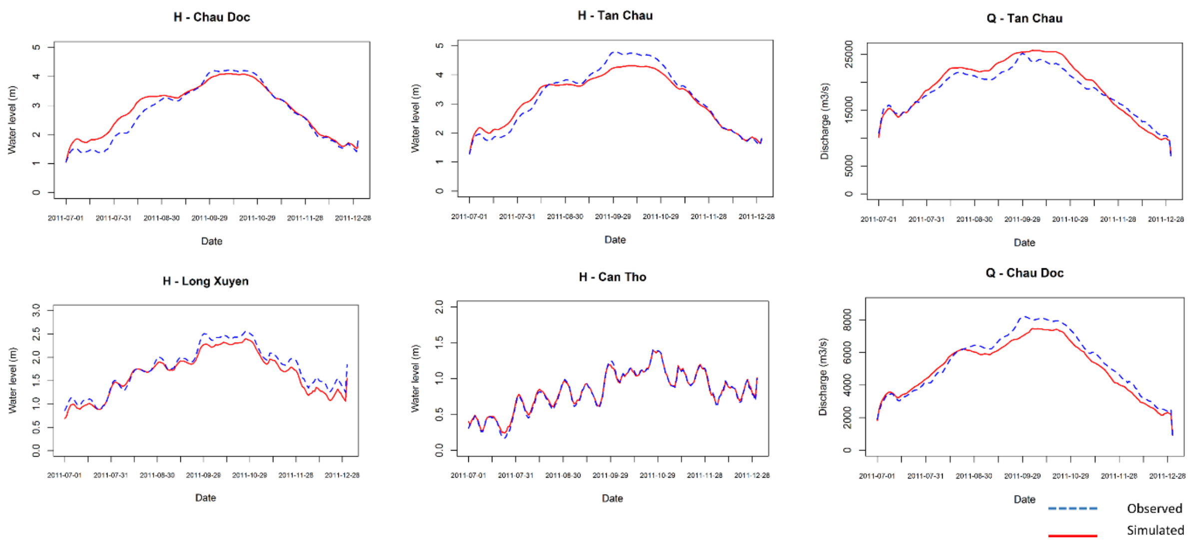

Figure 3: Time-series of simulated and observed flows in 2011 at representative stations

In Supplement:

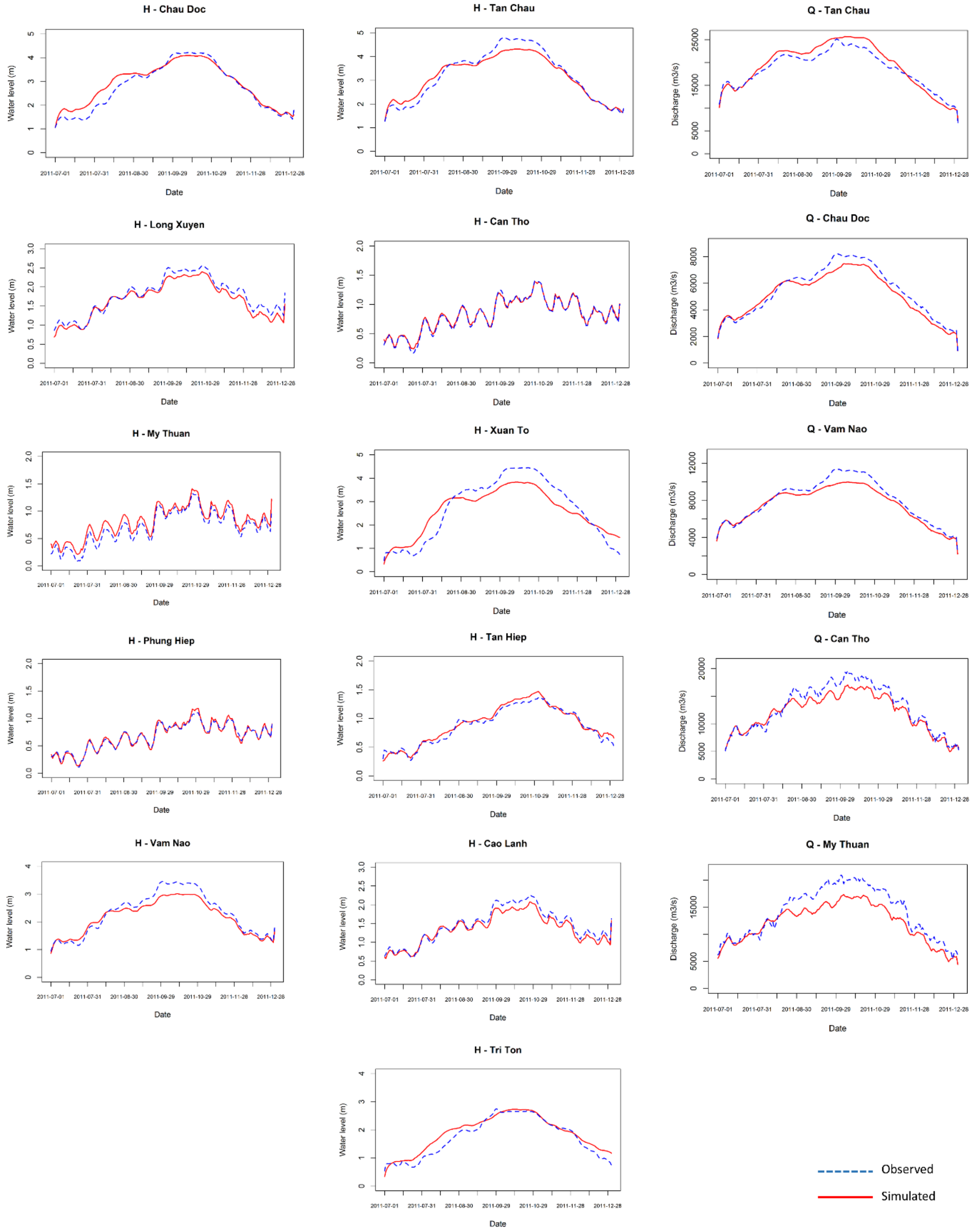

Figure S2: Time-series of daily simulated and observed flows in 2011 at all stations used for model calibration

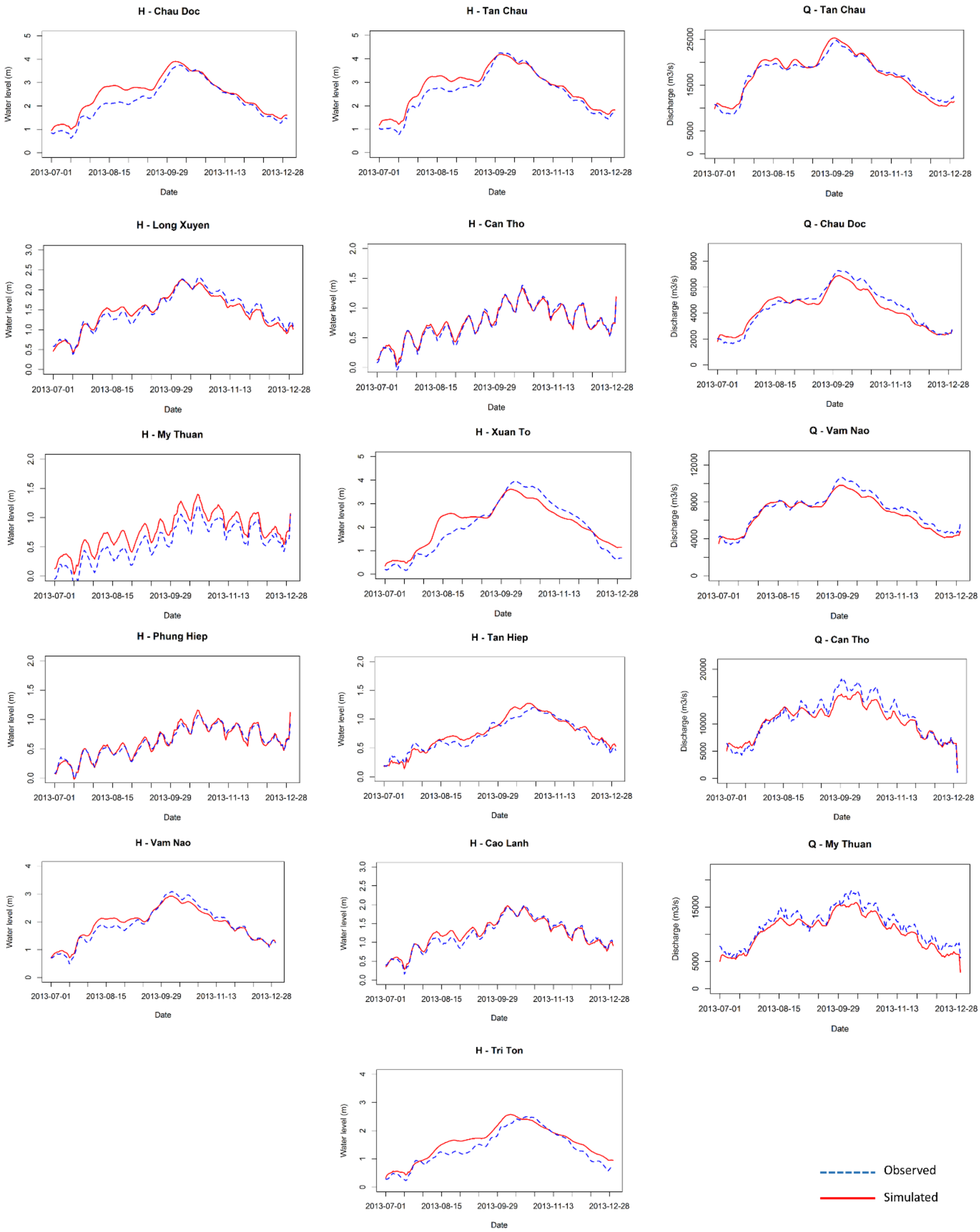

Figure S3: Time-series of daily simulated and observed flows in 2013 at all stations used for model calibration

15. Comment P15 Ln12-13: The x-axis of figure 4 should be the distance instead of the sites. I expect the explanation of underestimated simulated streamflow to be right after the figures.

Response: In the submitted manuscript, we used the 4 sites instead the distance shown in the axis because these are important points measured along the Hau River. For example, Chau Doc and Can Tho are two points we exlore the difference in measured water levels between the floods of 2000 and 2011. In addition, the x-axis of Figure 4 also shows the distance of 4 sites. We will add an explanation of underestimated simulated streamflow from Figure 4 (below).

We will add an explanation to Figure 4:

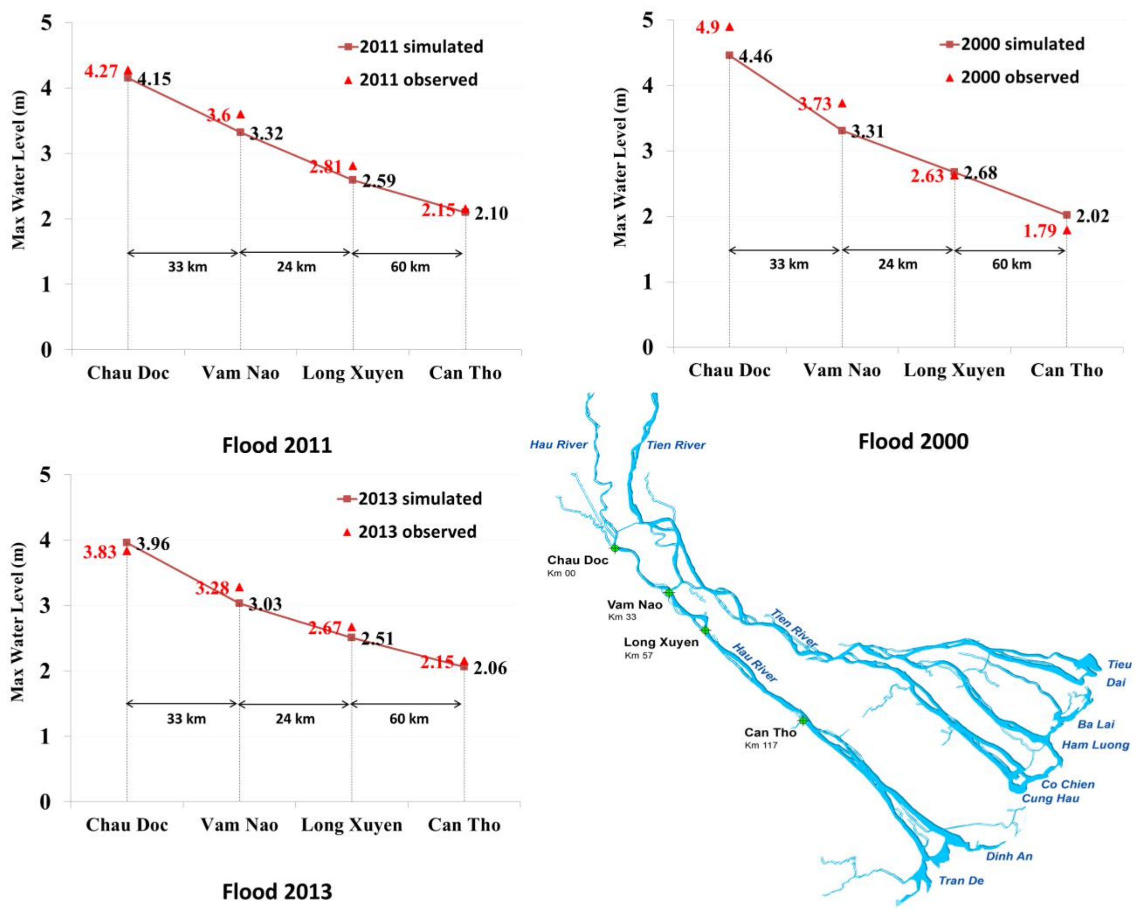

Figure 4: Simulated and observed maximum water levels for the 2000, 2011 and 2013 flood years at 4 different stations along the Hau River.

Added text right after the figure: *"The figure shows a good fitness of simulated and observed peak water levels in floods of 2011(calibration) and 2013 (validation). In the flood 2000, the fitness is low due to the significant changes in physical topography such as river cross-sections between the model setup of 2011 and the measured data in 2000."*

16. Comment P15 Ln20: Should be 2011?

Response: We will correct the number to "2011".

17. Comment P17 Ln5-6, Ln 15: A general comment: The authors should use more quantitative criteria to demonstrate either the difference or similarity between different scenarios. Statistical measures are highly desired.

Response: We thank for the comment of Reviewer#1. We will add some statistical calculations to the Supplement to present the difference and similarity between water levels in different dike scenarios. In addition, we will explain whether there are significant differences in the water levels or not in the text of the revised manuscript.

In Supplement:

Table S1: Paired sample test for water level time series along the Hau River in 2011

Scenario and Difference	N	Mean	Peak	Peak Time	Std. Deviation	95% Confidence interval of the difference		t-value	df	p-value
						Lower	Upper			
Paired Sample Test for water level (m) time series at Chau Doc										
S1	4393	2.567	3.486	12/10/2011	0.669					
S2	4393	2.908	4.152	12/10/2011	0.882					
S3	4393	2.912	4.166	12/10/2011	0.885					
S4	4393	2.920	4.179	12/10/2011	0.890					
Pair S1-S2						-0.374	-0.308	-20.415	8188	0.000
Pair S1-S3						-0.377	-0.311	-20.569	8175	0.000
Pair S1-S4						-0.385	-0.319	-20.968	8153	0.000
Paired Sample Test for water level (m) time series at Vam Nao										
S1	4393	1.937	2.664	13/10/2011	0.521					
S2	4393	2.030	2.943	26/10/2011	0.583					
S3	4393	2.035	2.963	26/10/2011	0.588					
S4	4393	2.040	2.975	26/10/2011	0.593					
Pair S1-S2						-0.116	-0.070	-7.914	8674	0.000
Pair S1-S3						-0.122	-0.075	-8.304	8656	0.000
Pair S1-S4						-0.127	-0.081	-8.726	8640	0.000
Paired Sample Test for water level (m) time series at Long Xuyen										
S1	4393	1.654	2.431	27/10/2011	0.499					
S2	4393	1.653	2.593	27/10/2011	0.509					
S3	4393	1.658	2.614	26/10/2011	0.514					
S4	4393	1.664	2.625	26/10/2011	0.519					
Pair S1-S2						-0.020	0.022	0.083	8780	0.934
Pair S1-S3						-0.025	0.017	-0.370	8776	0.711
Pair S1-S4						-0.031	0.012	-0.862	8771	0.389
Paired Sample Test for water level (m) time series at Can Tho										
S1	4393	0.843	2.054	27/10/2011	0.480					
S2	4393	0.829	2.098	27/10/2011	0.499					
S3	4393	0.830	2.102	27/10/2011	0.499					
S4	4393	0.832	2.106	27/10/2011	0.500					
Pair S1-S2						-0.006	0.035	1.368	8771	0.172
Pair S1-S3						-0.008	0.033	1.197	8770	0.231
Pair S1-S4						-0.010	0.031	1.008	8770	0.314

18. Comment P17 Ln 20-23: The authors should provide a more detailed explanation of the "hinge response". A modified hydrograph as forcing should be presented in the paper as well to help readers understand the "hinge response".

Response: Based on the responses of both reviewers we have come to the conclusion that the use of the term "hinge response" is confusing. Therefore in the revised version of the paper, we will not use the term "hinge response" anymore. We will also rename this section in chapter 4

19. Comment P21 Discussion section: In general, I think the discussion section is too long and verbose. The discussion must be shortened with clearer statements for each analysis. The authors can also try to reconstruct the discussions with results section to help the readers better understand the highlighted study results.

Response: We will shorten the Discussion section to help readers have better understanding about the significance of the study results.

20. Comment P26: Again, a reconstruction of discussion and conclusion sections is needed for this paper. I strongly recommend the authors to use bullets to clearly state the major findings of this study in the conclusion part. Tables and figures should be listed separately. Why did you list the peak water levels in Table 4 instead of plotting in the figures? Probably try to plot the peak water levels under different dike construction as well unless any other reasons.

Response: We will substantially revise and tighten the structure of the discussion section and create better links to the main results. We will also rewrite the Conclusion section by using bullets to state the major findings. Regarding Table 4, we would like to keep it in the revised manuscript because we want to show the detailed differences between peak floodwater levels in different points on canals of the floodplain.

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